

# LOW LAKE LEVEL DUE TO CHANGE IN CLIMATE

Lester H. Murdoch, Section Director of Weather Bureau, Writes on Conditions.

## PRECIPITATION CYCLES

Dry Period to Be Succeeded by Wet Era and High Water.

Is our climate changing? If this question were asked 100 men of mature years, at least ninety of them would answer in the affirmative.

In Utah, a cycle of unusually heavy precipitation began in 1856 and continued until 1885. During that period, the old settlers confidently asserted that the climate had changed to wetter, and even men of scientific training tried to explain the increased precipitation as due to human agencies. It was stated that the humidity had been greatly increased by breaking up the land, irrigation, increased vegetation, etc. Since 1885, the precipitation has been deficient, and nothing is now heard on the subject of human agencies increasing the humidity. Most men who spent their youth between 1856 and 1885 will now tell you that our climate has changed to drier.

### Great Change in the Past.

It is, therefore, evident that the person who forms the opinion that climate is changing, based upon his own personal experience, is very likely to be mistaken. And yet no one who has stood near Salt Lake City and observed on the mountain sides the shore lines of the ancient Lake Bonneville, can doubt for a minute that the climate of the Great Basin has undergone a very decided change. The maximum height of the old fresh water lake was about 1,000 feet above its present level, and its depth at the point where Salt Lake City now stands was something like 900 feet. Lake Bonneville covered the western half of Utah and small portions of eastern Nevada and southern Idaho. Its waters were discharged through Red Rock pass, in southern Idaho, and finally reached the Pacific ocean through the Columbia river. During the existence of the lake, its outlet was lowered 375 feet by erosion, producing a corresponding fall in the lake itself.

The lake existed as long as precipitation was in excess of the evaporation, and this was for thousands of years. Finally a change in climate caused the evaporation to exceed the precipitation, with the result that the lake dropped below its outlet. The fall has continued until there now remains only a comparatively small body of nearly saturated brine—Great Salt Lake—or, indeed, it may be that all water disappeared from the basin and that the present lake is the result of a swelling back to more humid conditions. The mere fact that a lake has disappeared does not necessarily demonstrate that this change is due to increased evaporation or diminished rainfall, but after careful investigation of the subject, the writer concludes that the disappearance of Lake Bonneville can be accounted for only by a change in climate.

### Era of Transformation Long.

Gilbert calculates that it would take 2,000 years for Great Salt Lake to accumulate its present supply of chlorine. From this data some idea may be obtained of the centuries that have elapsed since the time of Lake Bonneville. His studies of this region also show that preceding the epoch of high water was a period during which the basin was nearly or quite dry. This period exceeds in length the time that has elapsed since the Lake Bonneville epoch. And still preceding that period of drought was another humid epoch during which the water rose to within ninety feet of the Lake Bonneville stage and continued five times as long. Geologists generally agree that there were two periods of glaciation on the northern hemisphere. An epoch of much warmer weather separates the two, during which most of the ice disappeared. It seems probable that the two great lakes which have covered this basin were produced by the same conditions which caused the two periods of glaciation and were, therefore, coexistent with them.

Many theories have been advanced to explain these great vicissitudes of climate, but the question is far from settled.

### Precipitation Goes in Cycles.

The changes in climate which geology shows have taken place are so slow that they probably would not be appreciable in the most carefully kept record in a thousand years, but a study of the precipitation record of any locality will show that there are extended periods of comparatively dry weather followed by a number of years with excessive precipitation, and these in turn by a cycle of dry years. During the twenty-one years from 1856 to 1886, the average annual precipitation at Salt Lake City was 18.49 inches, or 1.84 inches more than the average for the entire record, and, during the first thirteen years of this wet cycle the average precipitation was 20.05 inches, or



LESTER H. MURDOCH. —Photo by Fries.

3.43 inches greater than the average for all years. The average precipitation for the fifteen years from 1887 to 1901 was only 15 inches, which is 1.65 inches below the average for all years.

While no authentic rain gauge records were kept in this vicinity prior to 1886, a very good record of the precipitation was kept by the water level of Great Salt Lake. This wonderful lake served as a very good rain gauge for the basin which it drains until irrigation and other processes of agriculture, following the settlement of the state, interfered with its catch. The accompanying chart shows how nicely the water level has responded to the precipitation until the last few years. As a result of the excessive precipitation, the lake reached a maximum level of about thirteen feet in 1885 and again in 1875. The maximum level for 1886 was a little over nine feet, but responding to the dry cycle which began the following year, a fall began and continues at the present time. The level on Nov. 15, 1902, was three feet three inches below the zero of the gauge, showing a decline of over twelve feet since 1886 and an extreme range of about sixteen feet.

### Irrigation a Factor.

Irrigation has undoubtedly been a factor in bringing about the present low level, but it is equally certain that the main factor has been the shortage in precipitation. The divergence between the precipitation and lake lines for the last few years is evidently due, in part at least, to the accumulative effects of the drought.

When the Mormon settlers entered the valley in 1847 the lake level was nearly as low as at present. The position of the storm line and the growth of the sage and other brush down to this line led Gilbert to conclude that it had been many years, and perhaps centuries, since the lake had been above the storm line of 1847. In order to throw further light upon the subject, the writer made an examination of the lake shore to determine how far down the brush is now growing. A fairly good growth of sagebrush and greasewood was found between the 1875 and 1886 lines, greasewood predominating. The growth of brush on the shore in 1847, therefore, cannot be used to prove that the low water of that period had existed a greater time than from sixteen to twenty-six years, but from all data available it seems more than probable that it had existed for at least twenty years. This being the case, it can be assumed that a dry cycle began in Utah as early as 1827; this cycle continued until 1864, or about thirty-seven years. Judging from the lake level, it is safe to estimate that the average annual precipitation during these years was not over fifteen inches.

### Dry Cycle Now On.

For Salt Lake City, then, we have a dry cycle extending from 1827 to 1864, during which the average annual precipitation was about fifteen inches; from 1865 to 1886, a wet cycle, with an average annual precipitation of 18.49 inches, and from 1887 to the present time a dry cycle, the average annual precipitation from 1887 to 1901 being fifteen inches.

Having outlined the wet and dry cycles for Salt Lake City, it will now be found both interesting and instructive to examine the records of other localities for the same purpose. The stations selected are in about the same latitude as Salt Lake City and include San Francisco, Sacramento, Denver, Omaha, St. Louis, Cincinnati and Baltimore. The wettest twenty consecutive years at both San Francisco and Sacramento, records extending back to 1850, were from 1866 to

1885; at Denver, the seventeen years from the beginning of the record, in 1870, to 1886, were the wettest; the record was begun at Omaha in 1871 and shows the first sixteen years to be the wettest; the wettest twenty consecutive years at St. Louis and Cincinnati, records extending back to 1839 and 1838, respectively, were from 1840 to 1859; at Baltimore this record was broken prior to 1871, and the wettest twenty consecutive years there were found from 1872 to 1892.

### Wet Belt Moves About.

From the foregoing it appears that the country west of the Rock mountains had its wettest cycle from 1865 to 1887, while the middle Mississippi and Ohio valleys received their heaviest precipitation from 1840 to 1859. It will be observed that while the central portion of the country was receiving an abundance of moisture, the country west of the Rock mountains was passing through the longest dry cycle of which we have any record. But of the dry cycle we are in at present is general from San Francisco to Baltimore. The past fifteen years have been the driest fifteen consecutive years on record for all the stations named, except Sacramento, and the drought is equally well marked there, but the fifteen years from 1851 to 1865 were a trifle drier.

How long will the present dry cycle continue? A correct answer to this question would be worth millions of dollars to the people of the United States and be especially valuable to those living in the arid regions.

### "Dry" Farming Unpopular.

During the first few years after Utah was settled no "dry" farming was attempted; but during the latter part of the sixties, after an apparent change in climate, it was found that handsome crops of grain could be raised without irrigation, and more and more land was broken up for this "dry" farming. During the past fifteen years "dry" farming has generally been a failure and is now being largely abandoned, and in several settlements, mostly in the west central portion of the state, irrigation water has been so scarce that very small crops have been raised for several years, and if a continuance of the dry cycle could be forecast, there would be a general exodus from those parts.

The Southern Pacific company is extending its road across the north end of Great Salt Lake. Judging from past levels, the track should be placed from sixteen to twenty feet above the present level to provide for high water. If it could be forecast that the present dry cycle would continue twenty years longer, it would probably mean a saving of at least \$1,000,000 to this company alone. And still another case in point is that of the Great Lakes, which have become so low in recent years as to interfere with navigation. The government has made financial provision for investigating this difficulty and for the formation of a practical plan for raising the water level. The level will probably be raised by the construction of a dam costing millions of dollars. If it were known that the next twenty years would be unusually wet, this expense would be unnecessary for the present.

### Sun Spots Do Not Affect Rain.

Many students of the subject have studied the fluctuations in weather conditions as dependent upon sun spot cycles. The investigations of Wolf and Wolfer of Switzerland show that the short cycles vary in length from 9.0 to 13.6 years, and that there are grand cycles of increase and decrease, both seeming to cover a period of about fifty-five years.

In comparing precipitation records with sun spots, some investigators have found that a maximum of sun spots is accompanied by a deficiency of precipitation and a minimum, by an excess; while others, equally as reliable, but using the precipitation records of different localities, have found the opposite conditions to exist.

The writer has compared the Salt Lake City precipitation record with Wolfer's sun spot tables, published in the Monthly Weather Review for April, 1902, but has been unable to discover any relation whatever between them. Years of minimum sun spots are sometimes excessively wet and sometimes excessively dry, and the same may be said of years of maximum sun spots. It seems pretty well settled that no well defined connection exists between the short sun spot cycles and the precipitation; and this may also be said of the fifty-five-year periods. But in the latter case the precipitation records are too short to permit a full investigation of the subject. But there are sufficient data to show that if a relationship does exist, it is rather complex. For example, the sun spot curve for the period from 1840 to 1859 does not appear to differ materially from that from 1857 to 1901. During the first period the central portion of the United States was in a wet cycle, while the country west of the Rocky mountains was in a very dry one. During the latter period a dry cycle prevailed from San Francisco to Baltimore.

### Length of Dry Period Uncertain.

We shall, therefore, have to conclude that there is no known natural law by which we can predict the length of the present dry cycle. The data shows that weather equally as dry prevailed west of the Rocky mountains for a period of at least thirty-seven years. If it were known that the recurring periods were of equal length, no change for the better could be expected in the intermountain country until about 1924, but it is probable that these periods vary in length, and if this be true, they cannot be used as an index to the future until much more data and knowledge are accumulated.

## BURGLARS ARE BUSY

Brigham Street House Broken Into—Crooks Enjoy the Paul Regime.

While Martin Hanson of 454 Brigham street, and his family, were away visiting friends on Saturday evening, burglars entered his home and ransacked it thoroughly. The Hansons left the house about 8 o'clock and returned shortly after 10 o'clock. When they entered the house they saw at once that an unbidden guest had been there. Bureau drawers had been emptied on the floor and their contents tossed about the room. Trunks had been broken into and even the beds disturbed in the search made by the burglar or burglars for money and jewelry. Fortunately for the Hansons, there was very little money in the house and no jewelry, and the victim of the night prowlers told the police that only a few small articles were missing and that the loss would not amount to more than a few dollars.

The thieves secured entrance to the house by prying open a rear window, and "jimmy"ing the door. The family away from home, they had ample opportunity to do their work, and they did it thoroughly. It is believed by the police that the burglars had heard from the sun of money which Hanson was supposed to have in the house, and that, watching their opportunity, they entered the premises to make a search for it, and not finding it, retired disappointed, taking with them a few souvenirs of their visit.

The burglary was reported to the police soon after it happened on Saturday night, but the fact that it had occurred was carefully suppressed by Chief Paul, who does not care to have the fact that crime is rampant in the town heralded more than he can help. Burglaries are of almost nightly occurrence and in no instance in the last few months has any arrest been made. The police are making four boys arrested yesterday for stealing four mouth organs. The gentlemen of the "jimmy" who do the large jobs, such as the robbery of the Sierra Nevada lumber company and the Continental Oil company, have not been caught, and it is believed that a gang of professional safe blowers and burglars are making their headquarters in the city, calm in the knowledge that the chief of police is much more likely to be nursing a sick horse at his livery barn than attending to his duties as chief of police.

## POPE GREETS CANADIANS.

Holy Father Intends to Meet Them Again Three Years Hence.

Rome, Nov. 23.—The pope today gave a farewell private audience to Archbishop Bruchesi of Montreal. His holiness afterwards went to the "Café de la Paix" where Mgr. Bruchesi presented to him all the Canadians now in Rome, numbering sixty. Pope Bruchesi said: "I hope to see your holiness on my next visit to Rome, three years hence. The pope promptly replied: 'I will wait for you.'"

### Minnesota Is Confident.

Chicago, Nov. 23.—The Minnesota football team passed through Chicago today en route to Mount Clemens, Mich., where it will play the next few days preparing for the Thanksgiving game with Michigan. Thorpe, the big halfback, was on crutches, but the rest of the team appeared to be in excellent condition and rather confident of defeating the Michigan team.

## NOW PREPARING THE REPORTS

Irrigation Field Work For the Season Has Ended.

## UTAH REPORT IS COMPLETED

IS A VALUABLE ADDITION TO IRRIGATION LITERATURE.

(Special to The Herald.)

CHEYENNE, Wyo., Nov. 23.—The field work of the irrigation investigations of the United States department of agriculture for 1902, under the supervision of officers of the local office, has been completed, and the members of the force who have been in the field have either returned or will soon return to headquarters to prepare the results of their summer's work for publication. C. G. Elliott, formerly editor of the Drainage Journal, has finished his drainage studies in Colorado. To enable him to give all of his time to this work, he has relinquished the editorship of the Drainage Journal, and has been succeeded by D. A. Anderson of Chicago, who hereafter will be at the head of both the Drainage Journal and the Irrigation Age.

Professor O. V. P. Stout of the University of Nebraska, who, in connection with Professor J. M. Wilson of the irrigation department of the University of California and Mr. Elliott, has been preparing working plans for the drainage of large areas in Idaho in California in 1900, and in Utah during the past two years.

Frank Bond, irrigation assistant, whose bulletin on rice culture in Louisiana and Texas has recently been issued, has continued his studies in those states.

Assistant Arthur P. Stover is co-operating with Director Samuel Porter of the Montana agricultural experiment station in the study of irrigation from the Gallatin river, near Bozeman, to the Yellowstone river, west of Billings, Mont. This work is the first of an investigation covering the state of Montana similar to that carried on in California in 1900, and in Utah during the past two years.

### Irrigation in Utah.

The most comprehensive report to be published during the year will be that on irrigation in Utah, which is now ready for the press. This report will include a general discussion of irrigation in Utah by William E. Smythe of California, and reports on Weber river, by J. D. Stannard; on Jordan river, by Ray P. Teale; on Provo and American Fork rivers, by Arthur P. Stover; on Spanish Fork river, by State Engineer A. F. Dorelius; on Logan river, by George L. Swenson, and on Virgin and Sevier rivers, by Frank Adams. This report will present the extent and methods of irrigation and the water right situation on the streams considered, and will be a valuable aid to lawmakers of Utah in framing a better irrigation code than that state now has.

"Irrigation in Egypt" is the title of the report Assistant Chief Clarence T. Johnston has prepared on his studies in Egypt last winter under special authority from the secretary of agriculture. This report has been completed and forwarded to the Washington office for publication. It will be a richly illustrated, comprehensive discussion of irrigation in the country where irrigation had its rise. Reports on Egyptian irrigation have been issued from time to time, but none has considered in so much detail the agricultural and water right phases treated by Professor Johnston. This report will therefore be a valuable addition to the already large amount of irrigation literature issued by the department of agriculture.

While people are clamoring for a share of the benefits of the recent irrigation act, many farmers are losing sight of the value of reservoirs in private ownership as they are found along the Cache, La Poudre and Big Thompson rivers in Colorado. The discussion of some of these typical reservoirs was published in the last year book of the department of agriculture, and further investigations have been carried on by Assistant Clarence T. Bait, who will shortly prepare a bulletin presenting the results of his study.

### Test Case Pending.

For a number of years the complications arising on interstate streams have been the subject of much discussion by those endeavoring to improve irrigation conditions in the west, and there is now in the United States supreme court a case brought by the state of Kansas, seeking to enjoin citizens of Colorado from continuing diversions from the Arkansas river. Because of the prominence of the interstate complications, the office of irrigation investigations in this city will make these its principal study during the season of 1903. In co-operation with the state engineers of Colorado, Wyoming and Nebraska, the office force will make a comprehensive study of the extent and conditions of irrigation from the North and South Platte rivers and of the main Platte below North Platte, Neb. Data will be gathered showing the history of settlement along these streams and of the use of water and the extent and character of the present use, the flow of the streams at the different state boundaries, and the number of rights to water already decreed; matters of irrigation practice, such as the duty of water, evaporation and seepage, and also the more difficult problem of underflow. W. B. Duntion of the office force has already begun the work by an examination of water right records of Wyoming and Colorado.

### BLAZE IN BALTIMORE.

Baltimore, Nov. 23.—A fire today in the umbrella factory of Gans Bros. caused \$200,000 damage to the building and stock. Both were fully insured.

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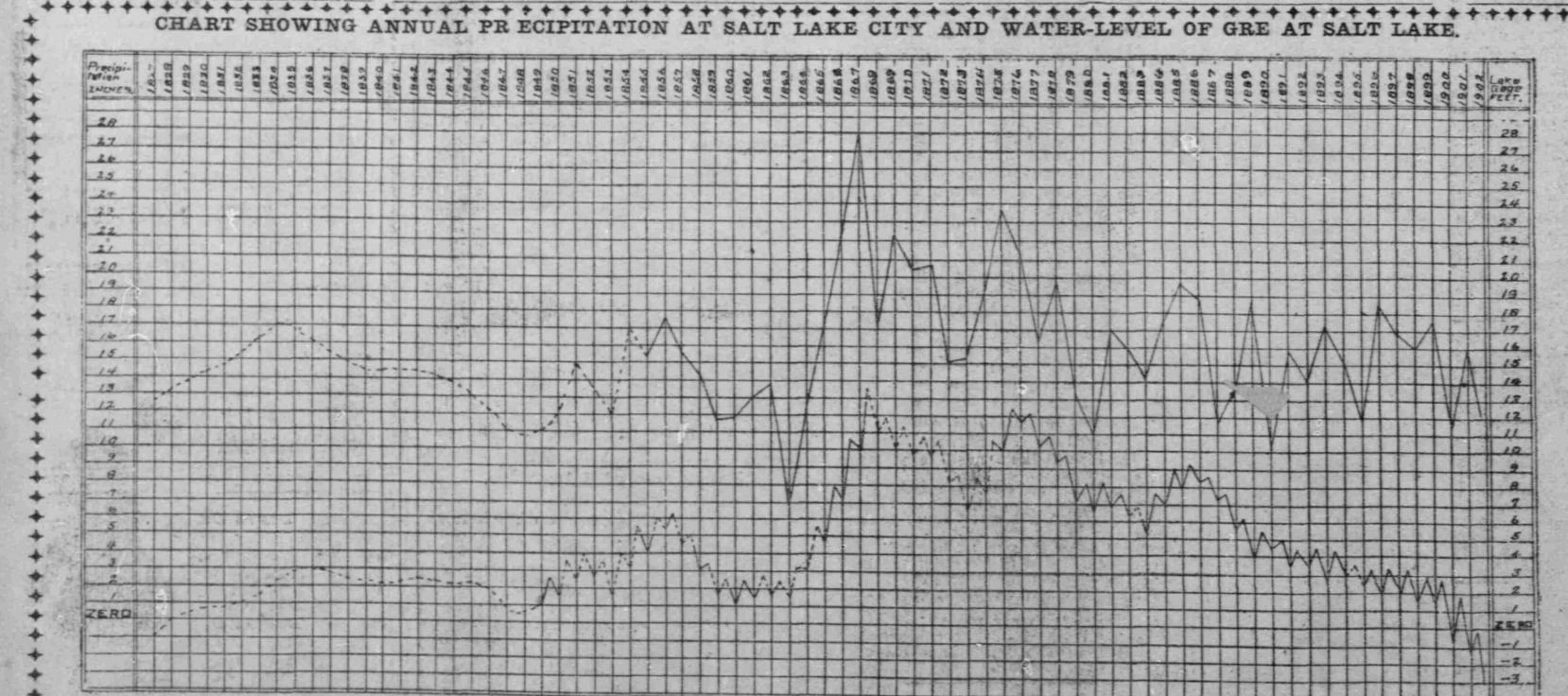
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EXPLANATORY NOTES.—The upper line indicates the precipitation and the lower line the lake level.  
Dotted lines indicate periods of no authentic observations, or that the data has been approximated; the position of the storm line in 1847 and the growth of sagebrush down there are the only data upon which both the lake and precipitation lines prior to 1847 are based, except an observation by Fremont in 1845.  
The precipitation record at Salt Lake City for 1902 does not fairly represent condition for the entire drainage basin; from May 2 to 4, 4.08 inches of rain fell at Salt Lake City, but this excessive precipitation covered only Salt Lake, Davis and small portions of adjoining counties, about one-twentieth of the basin, while the rainfall was comparatively light over other portions.